Small Business Innovation Research/Small Business Tech Transfer

Wafer Level Hybrid Interconnect Aligned (Cu/Oxide) Bonding for 3D Integration of Heterogenous (Si/GaAs) Submillimeter-Wave Arrays, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

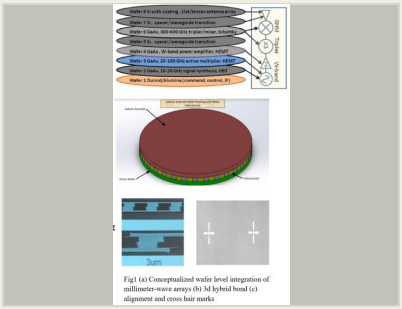
The objective of this work is to develop millimeter wave arrays with ultra-high accuracy alignment (<300nm) using hybrid aligned bonding. Currently, most submillimeter-wave array systems utilize a single pixel both for space as well as ground applications. While these approaches are workable for the near-term, they will become unsustainable as pixel count is increased. In addition, the shear mass associated with large count heterodyne arrays based on single waveguide block per chip approaches can be a challenging task. In this project, we present a 3D wafer level integration of this technology using low cost aligned direct wafer bonding at low temperature of 200^0C. This wafer level integration may decrease 50-100x in both volume and mass, hence reduces thermal gradient. As of today, most of the gain fluctuations in this device are coming from thermal gradients. By reducing the size and mass of the radiometer, the thermal gradients, these devices will be able to be used in balloons, landers, overs, and any other place where a complete remote chemical laboratory might be required.

In order to realize this high-performance device, the alignment requirement for wafer level interconnect in millimeter arrays needs to be very tight, close to 300nm or better. It depends on feature size of the interconnect at the wafers. **The wafer alignment needs to be optical before bonding two surfaces using alignment marks on both side of the wafers.** ***The bonding needs to be performed in a hybrid nature (Cu interconnect with oxide in the same layer) i.e. Cu/Cu, SiO2/SiO_2 Cu/GaAs oxides. at Phase I,*** We will conduct a feasibility study to develop an algorithm for advanced alignment <300nm. We will fine tune our proprietary method of wafer bonding for hybrid bond of Cu/SiO2 or Cu/SiO2/Ga_2O_3 & As_2O_3 . We will do feasibility of DRIE for TSV structures and Cu interconnect by damascene process. Finally, we will conduct feasibility of recess needed for good bond with high accuracy of alignment.

Anticipated Benefits

Submillimeter-wave spectrometry is a proven technique for atmospheric remote sensing, study of cosmic water profiles, comet characterization, investigation of cosmological phenomena with radio telescopes, imaging capability for both near field (i.e. sample tomography) and far field applications (i.e threat detection).

This compact semiconductor approach will enable large pixel count arrays with low mass and high functionality for both for ground-based applications as well as space exploration. With a size reduction, thermal stability, inter-component matching of this magnitude, these will be able to be used in balloons, landers, overs, and any other place where a complete remote chemical laboratory might be required.



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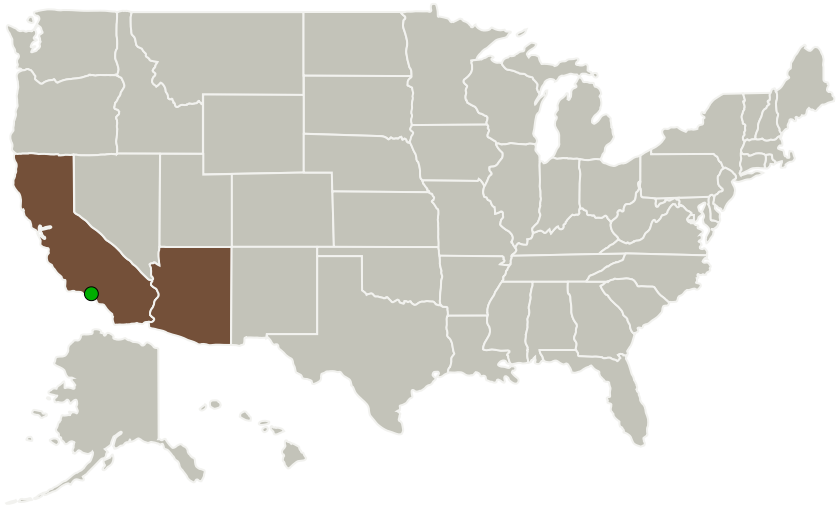
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Cactus Materials	Lead Organization	Industry Small Disadvantaged Business (SDB)	Chandler, Arizona
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations	
Arizona	California

Project Transitions

July 2018: Project Start

February 2019: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/141364)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Cactus Materials

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

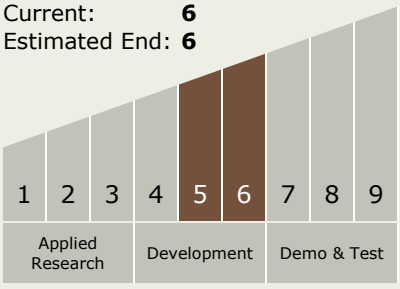
Carlos Torrez

Principal Investigator:

Mohammed R Islam

Technology Maturity (TRL)

Start: **5**
Current: **6**
Estimated End: **6**



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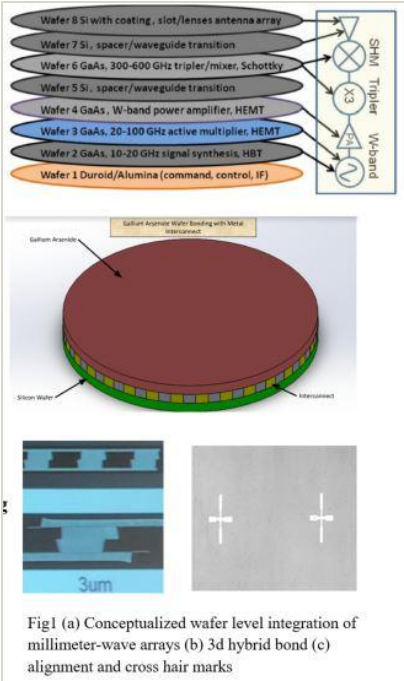
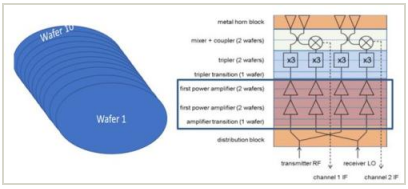
Images



Briefing Chart Image
Wafer Level Hybrid Interconnect Aligned (Cu/Oxide) Bonding for 3D Integration of Heterogenous (Si/GaAs) Submillimeter-Wave Arrays, Phase I
(https://techport.nasa.gov/image/130354)



Final Summary Chart Image
Wafer Level Hybrid Interconnect Aligned (Cu/Oxide) Bonding for 3D Integration of Heterogenous (Si/GaAs) Submillimeter-Wave Arrays, Phase I
(https://techport.nasa.gov/image/129206)

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destinations

Earth, The Moon, Mars